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Yamada

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(54) **STORAGE DEVICE AND METHOD FOR CONTROLLING STORAGE DEVICE**

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G06F 3/06 (2006.01)

(52) **U.S. Cl.**
CPC ***G06F 3/0652*** (2013.01); ***G06F 3/061*** (2013.01); ***G06F 3/065*** (2013.01); ***G06F 3/0608*** (2013.01); ***G06F 3/0644*** (2013.01); ***G06F 3/0689*** (2013.01); ***G06F 12/023*** (2013.01)

(58) **Field of Classification Search**
CPC . G06F 12/023; G06F 12/0292; G06F 3/0608; G06F 3/0644; G06F 3/065
See application file for complete search history.

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(57) **ABSTRACT**

A storage device includes a memory and a control device. The control device allocates a first storage region out of a plurality of storage regions to a first logical address specified by an external device. The control device stores, in the memory, first information associating the first logical address with a first physical address indicating the first storage region. The control device deletes, upon accepting a request for release of a second storage region indicated by a second physical address associated with a second logical address specified by the external device, second information associating the second logical address with the second physical address from the memory. The control device releases, when copy process of copying first data stored in the second storage region is unexecuted, the second storage region after finishing the copy process.

4 Claims, 14 Drawing Sheets

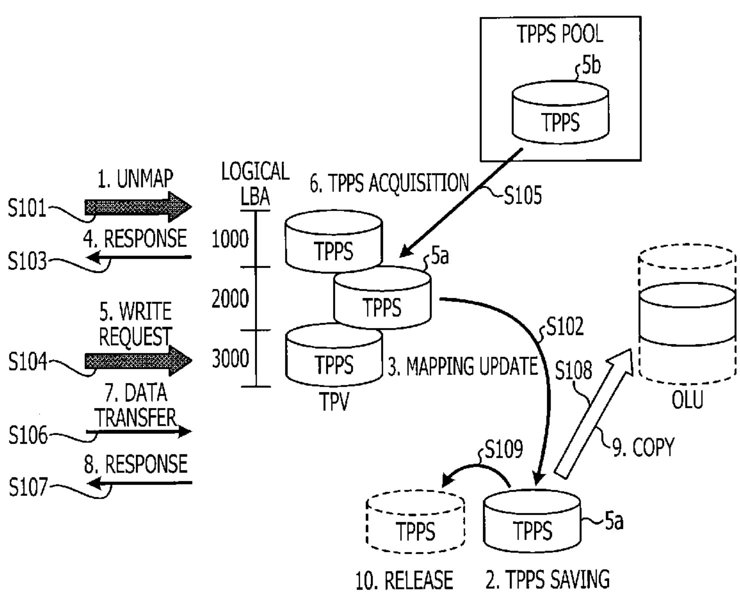


FIG. 1

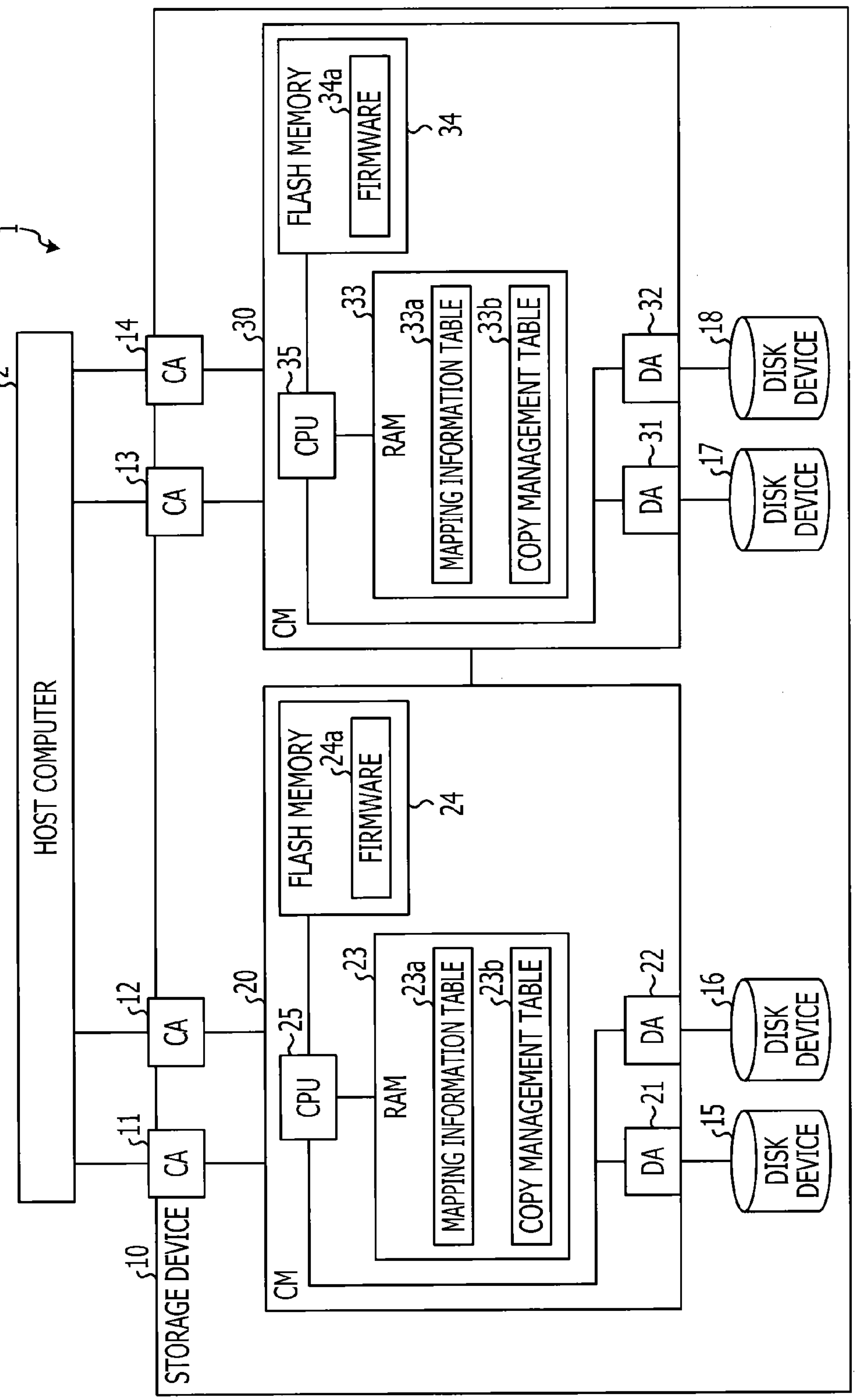

1
2
HOST COMPUTER
10
STORAGE DEVICE
11
12
13
14
CA
20
30
CM
CPU
25
35
RAM
23
33
23a
33a
MAPPING INFORMATION TABLE
23b
33b
COPY MANAGEMENT TABLE
FLASH MEMORY
24
34
24a
34a
FIRMWARE
DA
21
22
31
32
15
16
17
18
DISK DEVICE

FIG. 2

23a(33a)

LOGICAL LBA	PHYSICAL LBA
1000	35000(TPPS_10)
2000	47000(TPPS_22)
3000	37000(TPPS_12)

FIG. 3

23b(33b)

COPY SOURCE TPPS	COPY DESTINATION OLU	COPY DESTINATION LOGICAL LBA	STATE
TPPS_11	1	5000	FINISHED
TPPS_11	2	6000	FINISHED
TPPS_20	3	7000	IN EXECUTION

FIG. 4

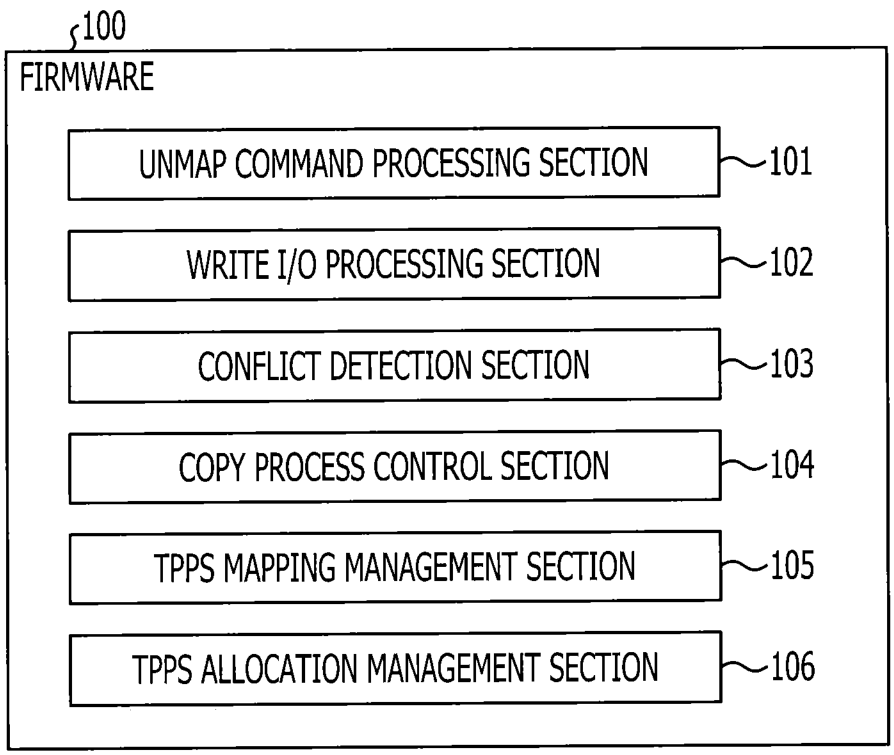
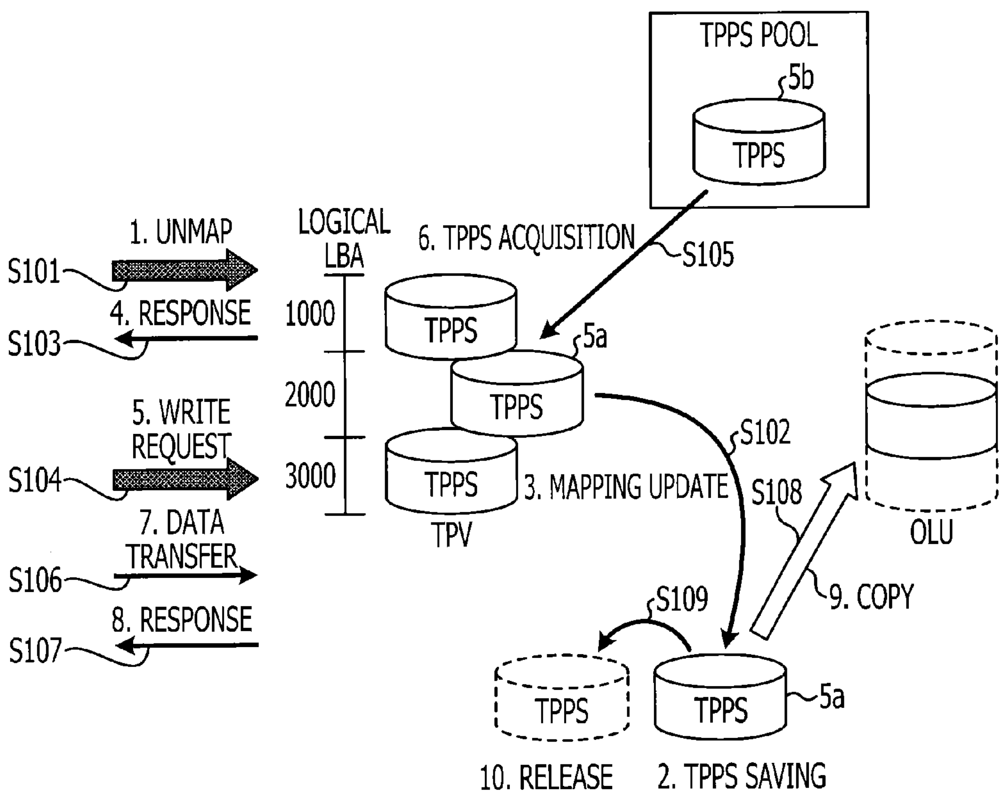

100
FIRMWARE
UNMAP COMMAND PROCESSING SECTION
101
WRITE I/O PROCESSING SECTION
102
CONFLICT DETECTION SECTION
103
COPY PROCESS CONTROL SECTION
104
TPPS MAPPING MANAGEMENT SECTION
105
TPPS ALLOCATION MANAGEMENT SECTION
106

FIG. 5



TPPS POOL
5b
TPPS
1. UNMAP
S101
LOGICAL
LBA
6. TPPS ACQUISITION
S105
4. RESPONSE
S103
1000
TPPS
5a
2000
TPPS
S102
5. WRITE
REQUEST
S104
3000
TPPS
3. MAPPING UPDATE
S108
TPV
OLU
7. DATA
TRANSFER
S106
9. COPY
S109
8. RESPONSE
S107
TPPS
TPPS
5a
10. RELEASE
2. TPPS SAVING

FIG. 6

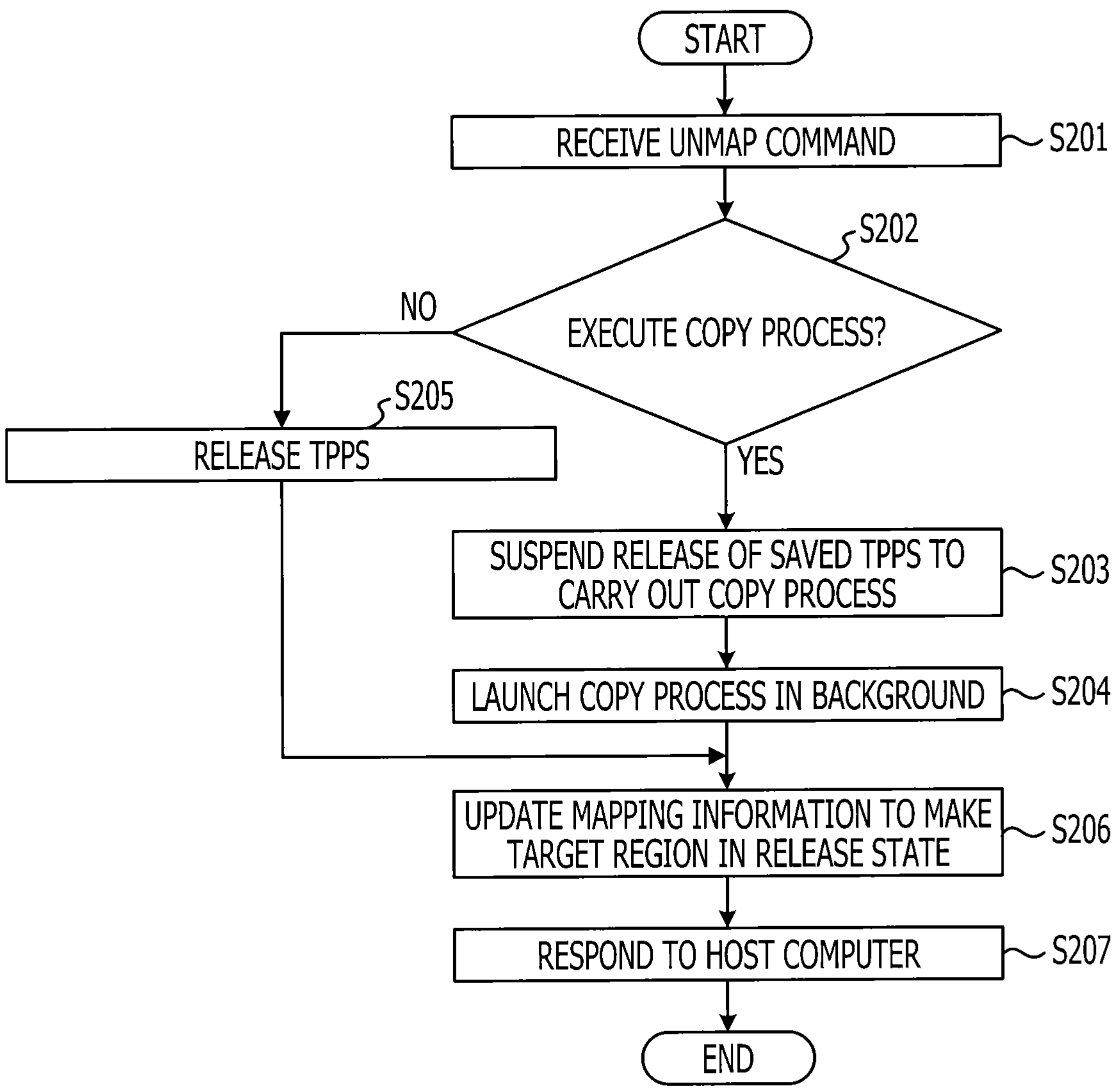

START
RECEIVE UNMAP COMMAND
S201
S202
EXECUTE COPY PROCESS?
NO
YES
S205
RELEASE TPPS
SUSPEND RELEASE OF SAVED TPPS TO CARRY OUT COPY PROCESS
S203
LAUNCH COPY PROCESS IN BACKGROUND
S204
UPDATE MAPPING INFORMATION TO MAKE TARGET REGION IN RELEASE STATE
S206
RESPOND TO HOST COMPUTER
S207
END

FIG. 7

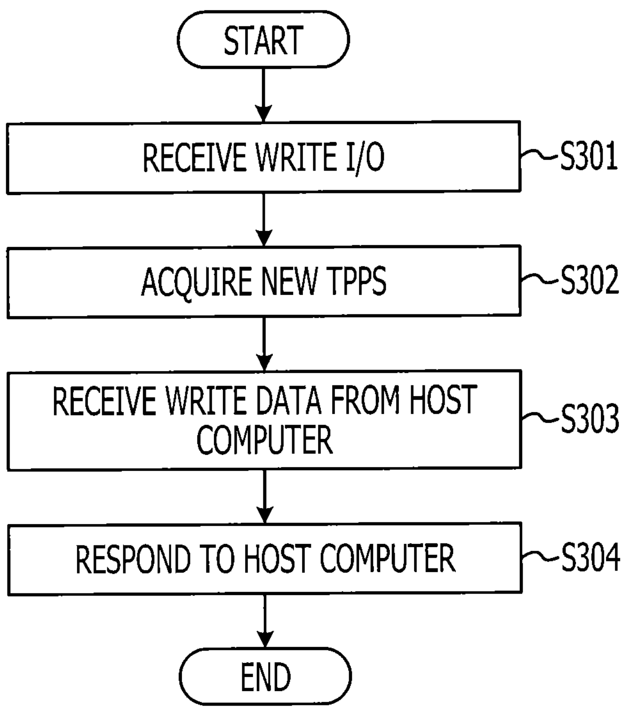

START
RECEIVE WRITE I/O
S301
ACQUIRE NEW TPPS
S302
RECEIVE WRITE DATA FROM HOST COMPUTER
S303
RESPOND TO HOST COMPUTER
S304
END

FIG. 8

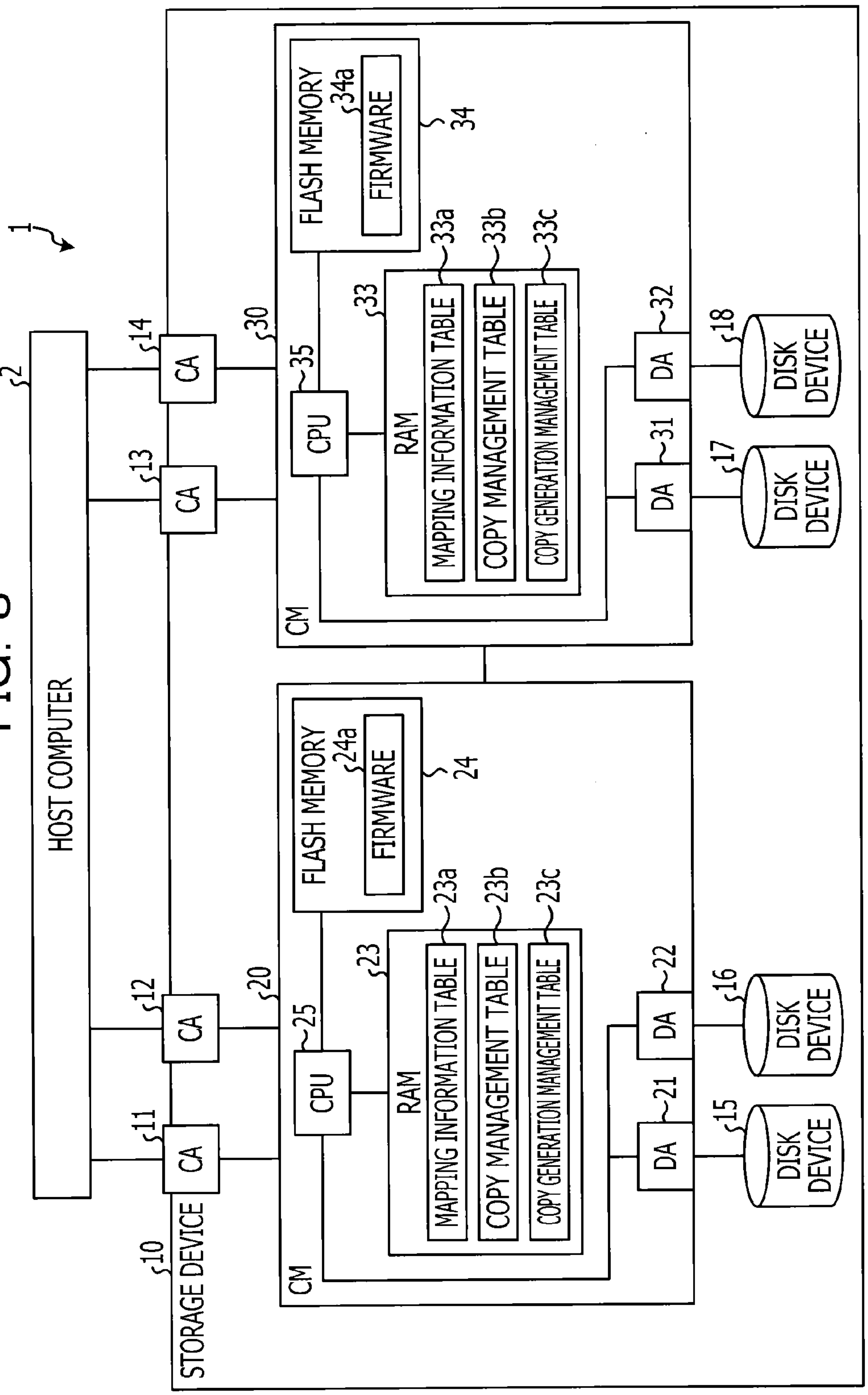

1
2
HOST COMPUTER
10
STORAGE DEVICE
11
CA
12
CA
13
CA
14
CA
20
CM
25
CPU
23
RAM
23a
MAPPING INFORMATION TABLE
23b
COPY MANAGEMENT TABLE
23c
COPY GENERATION MANAGEMENT TABLE
24
FLASH MEMORY
24a
FIRMWARE
21
DA
22
DA
15
DISK DEVICE
16
DISK DEVICE
30
CM
35
CPU
33
RAM
33a
MAPPING INFORMATION TABLE
33b
COPY MANAGEMENT TABLE
33c
COPY GENERATION MANAGEMENT TABLE
34
FLASH MEMORY
34a
FIRMWARE
31
DA
32
DA
17
DISK DEVICE
18
DISK DEVICE

FIG. 9

23c(33c)

COPY GENERATION	COPY SOURCE TPPS	COPY DESTINATION OLU	COPY DESTINATION LOGICAL LBA
1	TPPS_11	1	5000
2	TPPS_11	2	6000
3	TPPS_20	3	7000

FIG. 10

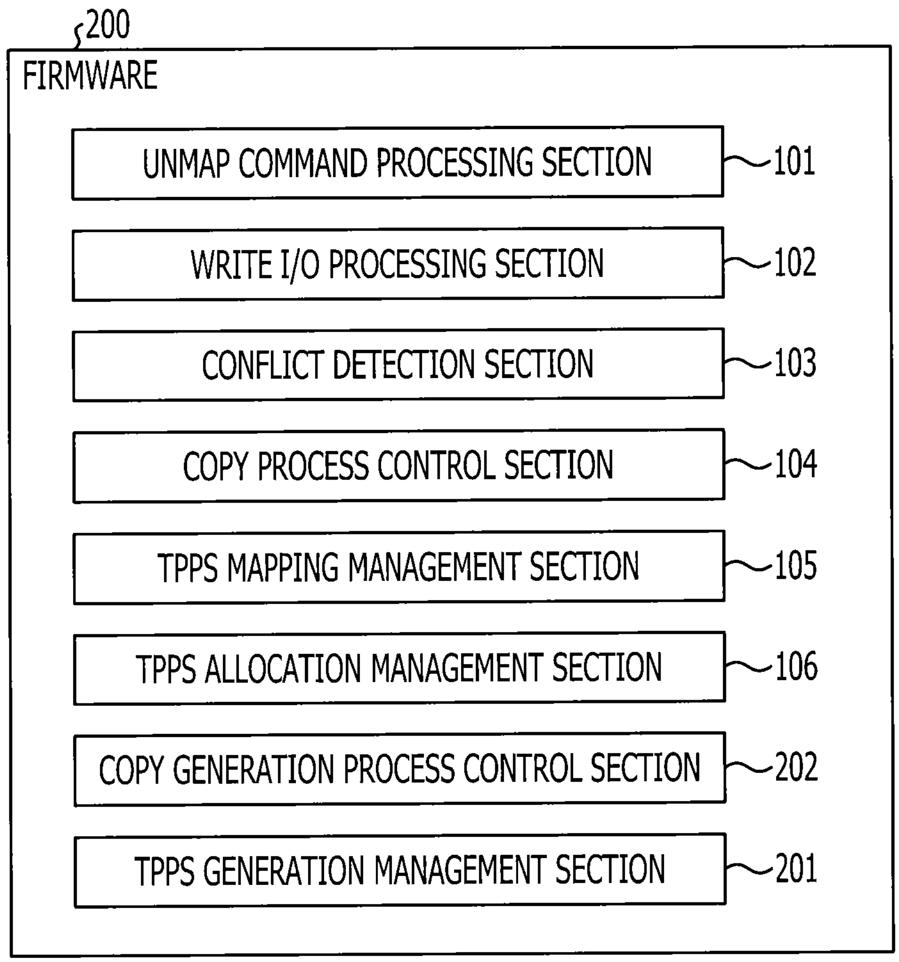

200
FIRMWARE
UNMAP COMMAND PROCESSING SECTION
101
WRITE I/O PROCESSING SECTION
102
CONFLICT DETECTION SECTION
103
COPY PROCESS CONTROL SECTION
104
TPPS MAPPING MANAGEMENT SECTION
105
TPPS ALLOCATION MANAGEMENT SECTION
106
COPY GENERATION PROCESS CONTROL SECTION
202
TPPS GENERATION MANAGEMENT SECTION
201

FIG. 11

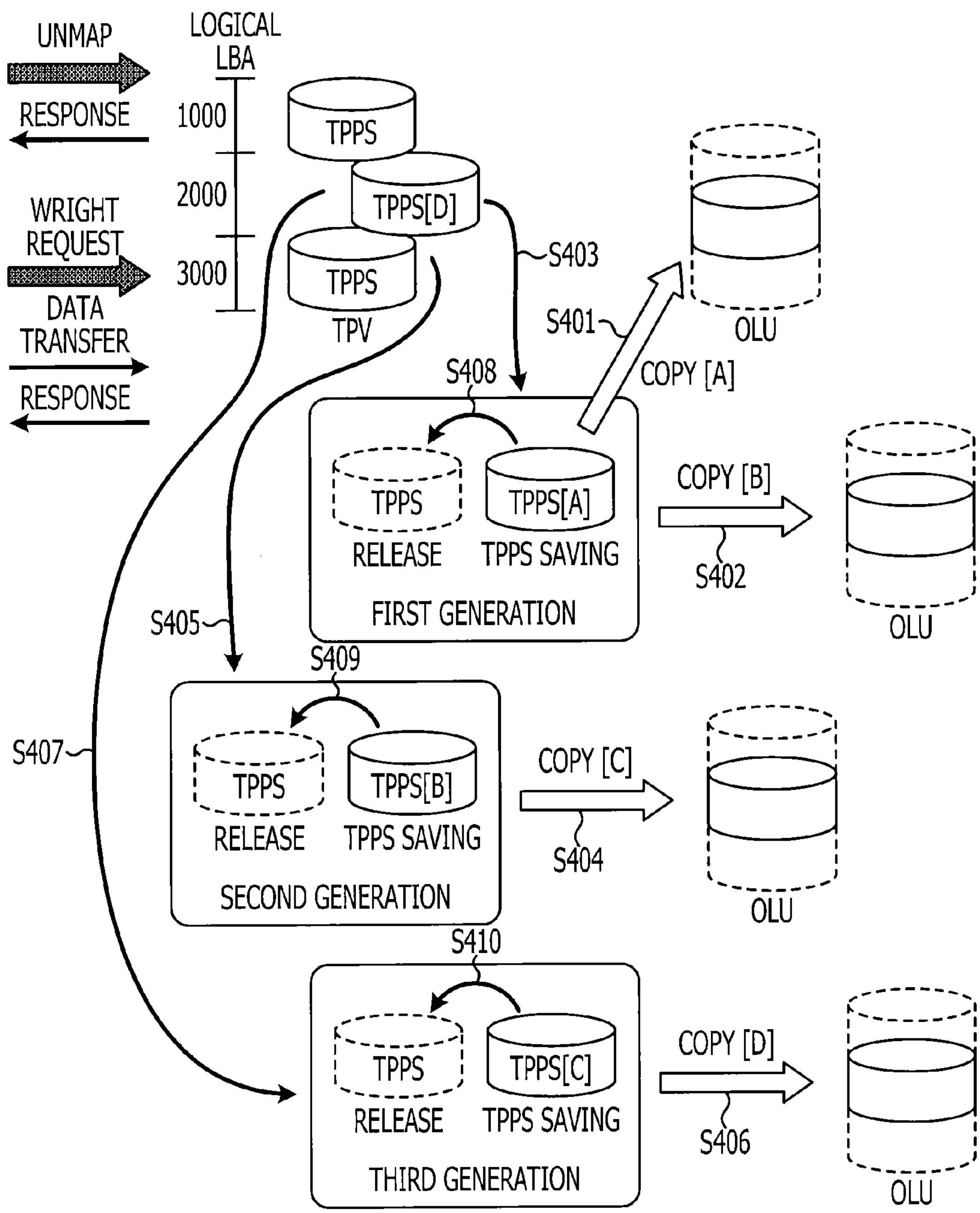

UNMAP
RESPONSE
WRIGHT REQUEST
DATA TRANSFER
RESPONSE
LOGICAL LBA
1000
2000
3000
TPPS
TPPS[D]
TPPS
TPV
S403
S401
COPY [A]
OLU
S408
TPPS
RELEASE
TPPS[A]
TPPS SAVING
FIRST GENERATION
COPY [B]
S402
OLU
S405
S409
TPPS
RELEASE
TPPS[B]
TPPS SAVING
SECOND GENERATION
COPY [C]
S404
OLU
S407
S410
TPPS
RELEASE
TPPS[C]
TPPS SAVING
THIRD GENERATION
COPY [D]
S406
OLU

FIG. 12

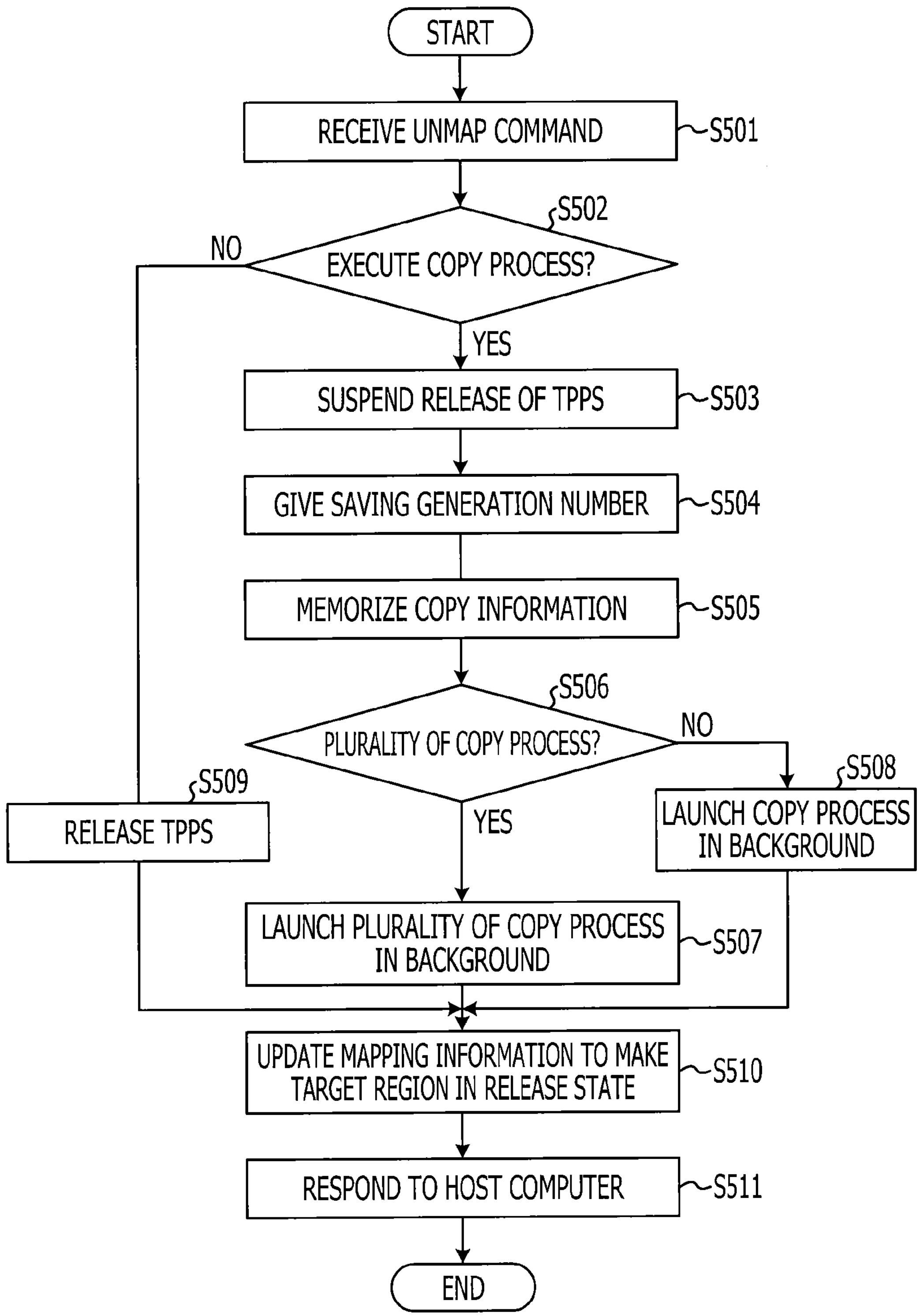

START
RECEIVE UNMAP COMMAND
S501
S502
EXECUTE COPY PROCESS?
NO
YES
SUSPEND RELEASE OF TPPS
S503
GIVE SAVING GENERATION NUMBER
S504
MEMORIZE COPY INFORMATION
S505
S506
PLURALITY OF COPY PROCESS?
NO
YES
S508
LAUNCH COPY PROCESS IN BACKGROUND
S509
RELEASE TPPS
LAUNCH PLURALITY OF COPY PROCESS IN BACKGROUND
S507
UPDATE MAPPING INFORMATION TO MAKE TARGET REGION IN RELEASE STATE
S510
RESPOND TO HOST COMPUTER
S511
END

FIG. 13

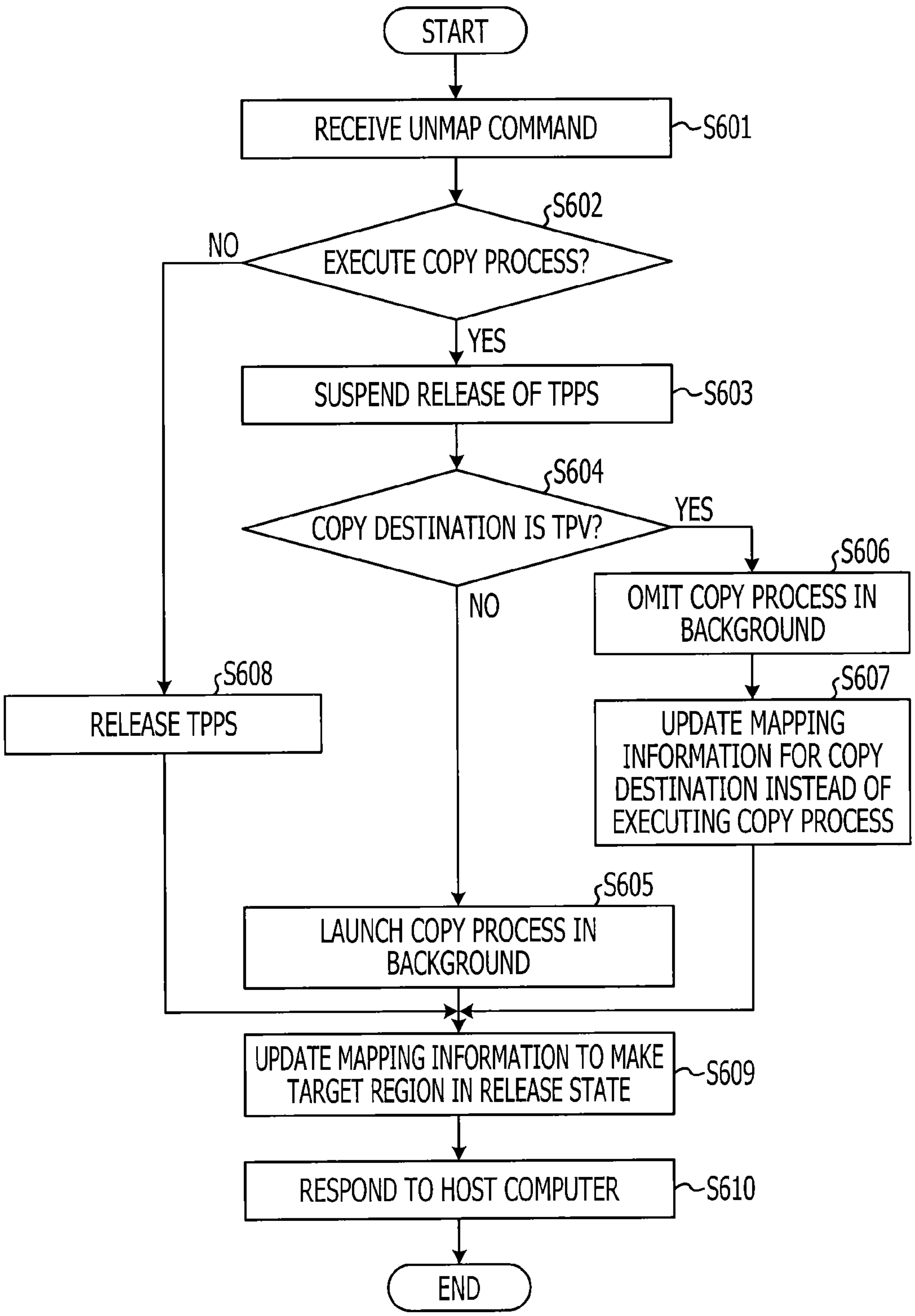
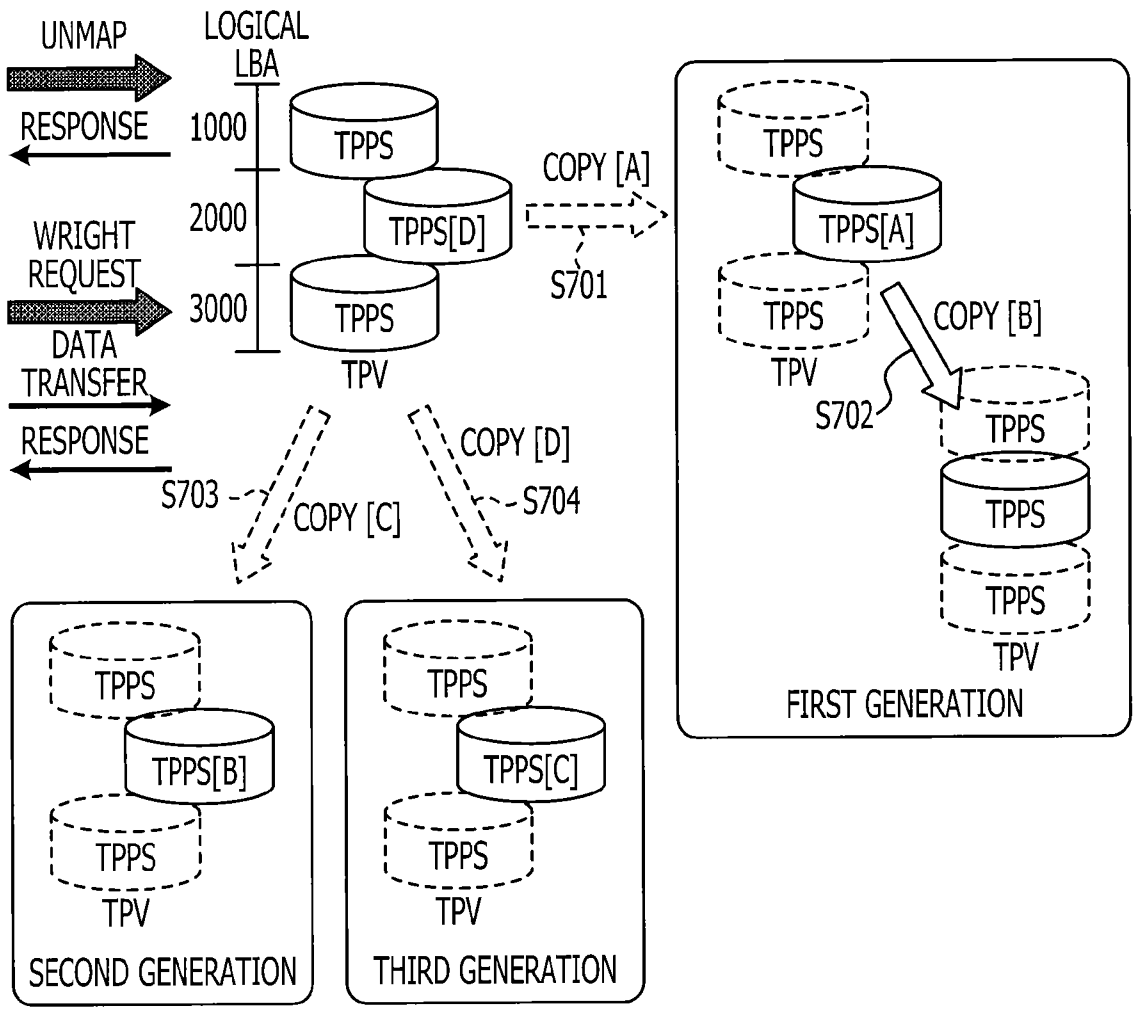

START
RECEIVE UNMAP COMMAND
S601
S602
EXECUTE COPY PROCESS?
NO
YES
SUSPEND RELEASE OF TPPS
S603
S604
COPY DESTINATION IS TPV?
YES
NO
S606
OMIT COPY PROCESS IN BACKGROUND
S607
UPDATE MAPPING INFORMATION FOR COPY DESTINATION INSTEAD OF EXECUTING COPY PROCESS
S608
RELEASE TPPS
S605
LAUNCH COPY PROCESS IN BACKGROUND
UPDATE MAPPING INFORMATION TO MAKE TARGET REGION IN RELEASE STATE
S609
RESPOND TO HOST COMPUTER
S610
END

FIG. 14


UNMAP
RESPONSE
LOGICAL LBA
1000
2000
3000
WRIGHT REQUEST
DATA TRANSFER
RESPONSE
TPPS
TPPS[D]
TPPS
TPV
COPY [A]
S701
TPPS
TPPS[A]
TPPS
TPV
COPY [B]
S702
TPPS
TPPS
TPPS
TPV
FIRST GENERATION
S703
COPY [C]
COPY [D]
S704
TPPS
TPPS[B]
TPPS
TPV
SECOND GENERATION
TPPS
TPPS[C]
TPPS
TPV
THIRD GENERATION

STORAGE DEVICE AND METHOD FOR CONTROLLING STORAGE DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

This application is based upon and claims the benefit of priority of the prior Japanese Patent Application No. 2012-118956, filed on May 24, 2012, the entire contents of which are incorporated herein by reference.

FIELD

The embodiments discussed herein are related to a storage device and a method for controlling a storage device.

BACKGROUND

In the past, in a case of receiving a request for allocation of, for example, 10 TB of storage area from a server, a storage device allocates a physical disk capacity of 10 TB. In contrast, there is a case that the server actually uses only 20% through 30% of the allocated amount out of the physical disk capacity allocated as requested. In such a manner, there is a case that a physical disk capacity allocated to a server is not utilized efficiently.

Given such a situation, as an arrangement for efficiently using a physical disk capacity of a storage device, there is a technique called thin provisioning. In thin provisioning, in a case of receiving a request for allocation of 10 TB from a server, for example, a storage device allocates a virtual volume of 10 TB to the server as requested, while actually allocating a physical disk capacity of only 2 TB.

Then, in a case that the server uses a physical disk capacity exceeding a predetermined threshold, the storage device allocates a fresh additional physical disk capacity to the server. In such a manner, thin provisioning allocates a physical disk capacity at the time of a host access request as the occasion arises. This enables the storage device to efficiently utilize the physical disk capacity. The virtual volume used at this time is called as a thin provisioning volume (TPV), and a smallest unit of the physical disk capacity allocated to the TPV is called as a thin provisioning pool slice (TPPS).

In a case that data is deleted by the server, the deleted data is handled as unused in the operating system (OS) of the server. In contrast, since the TPPS is still allocated to the deleted data in the storage device, the storage device turns out to consume the physical disk capacity uselessly.

As an arrangement to improve this, there is an UNMAP command. An UNMAP command is a command to request the TPV in the storage device for release of the TPPS by specifying a logical address of the unused TPPS. The server issues this UNMAP command to the storage device in coordination with the deletion of data, thereby efficiently operating the TPPS allocated by thin provisioning. The UNMAP command is one of vStorage APIs (application programming interfaces) for array integration (VAAI) out of storage APIs provided by VMware.

The storage device sometimes has a copy function of a snapshot type that logically copies TPPS data. The UNMAP command is allowed to be used together with the copy function executed by the storage device. For example, in a case that an UNMAP command is issued to uncopied TPPS data, the storage device copies the TPPS data and releases the TPPS after finishing the copy. Then, after releasing the TPPS, the storage device responds to the server for the UNMAP command.

The UNMAP command has a capacity, subjected to be processed in a single request from a host, from several GB to several tens of GB or even more, and in comparison with regular write I/O (input/output), the capacity subjected to be processed is large. Therefore, in a case that the storage device receives an UNMAP command and copies all the range requested by the UNMAP command, the time until the UNMAP command is executed increases. As a result, since the server is not able to receive a response to the UNMAP command until finishing TPPS release process by the storage device, there is a higher possibility that the UNMAP command is timed out.

Given such a situation, the storage device records that release process is in a state of being reserved for the TPPS requested for release and immediately returns a response to the UNMAP command to the server. Then, the storage device executes the release process asynchronously at the time of completion of saving the TPPS data to a copy destination to release the TPPS. In such a manner, the storage device keeps an UNMAP command issued to a region subjected to copy from being timed out.

Japanese Laid-open Patent Publication No. 2009-251970 and Japanese Laid-open Patent Publication No. 2011-13821 disclose related techniques.

However, the techniques in the past described above have a problem of delaying data writing that specifies a logical address specified in the request for release.

In a case that a request for writing data is issued to the TPPS of release process in a reserved state, the storage device puts the request for writing data on standby until the TPPS data is copied and the TPPS is released after finishing the copy. Therefore, the server is not able to receive a response to the request for writing data until finishing the TPPS release process by the storage device, and there is a higher possibility that the request for writing data is timed out.

In addition, the storage device sometimes executes copy of a snapshot type to identical TPPS data at different time. Then, in a case that, after an UNMAP command is issued to the TPPS of a copy source, a request for writing data is issued to the TPPS of release process in a reserved state, the request for writing data is put on standby until finishing the TPPS release process by the storage device. As a result, the possibility that the request for writing data is timed out becomes even higher.

Still in addition, the storage device sometimes executes an UNMAP command and copy of a snapshot type alternately. In such a case, a response performance of the data writing process to the TPPS of release process in a reserved state decreases chronically.

SUMMARY

According to an aspect of the present invention, provided is a storage device including a memory and a control device. The control device allocates a first storage region out of a plurality of storage regions to a first logical address specified by an external device. The control device stores, in the memory, first information associating the first logical address with a first physical address indicating the first storage region. The control device deletes, upon accepting a request for release of a second storage region indicated by a second physical address associated with a second logical address specified by the external device, second information associating the second logical address with the second physical address from the memory. The control device releases, when copy process of copying first data stored in the second storage region is unexecuted, the second storage region after finishing the copy process.

The object and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the claims.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a block diagram illustrating a configuration of an information processing system according to a first embodiment;

FIG. **2** is a chart illustrating one example of a data structure of data stored in a mapping information table;

FIG. **3** is a chart illustrating one example of a data structure of data stored in a copy management table;

FIG. **4** is a diagram illustrating a functional configuration of a storage device according to a first embodiment;

FIG. **5** is a diagram illustrating one example of process behaviors by a storage device according to a first embodiment;

FIG. **6** is a flowchart illustrating a process procedure of mapping information update process upon receiving an UNMAP command in the storage device according to a first embodiment;

FIG. **7** is a flowchart illustrating a process procedure of TPPS acquisition process when a write I/O is received in a storage device according to a first embodiment;

FIG. **8** is a block diagram illustrating a configuration of an information processing system according to a second embodiment;

FIG. **9** is a chart illustrating one example of a data structure of data stored in a copy generation management table;

FIG. **10** is a diagram illustrating one example of a functional configuration of a storage device according to the second embodiment;

FIG. **11** is a diagram illustrating one example of process behaviors by a storage device according to a second embodiment;

FIG. **12** is a flowchart illustrating a process procedure of mapping information update process by a storage device according to a second embodiment;

FIG. **13** is a flowchart illustrating a process procedure at the time of copy to a TPV by a storage device according to a third embodiment; and

FIG. **14** is a diagram illustrating one example of process behaviors by a storage device according to a third embodiment.

DESCRIPTION OF EMBODIMENTS

Detailed descriptions are given below to embodiments of a storage device and a method for controlling a storage device disclosed herein with reference to the drawings. Embodiments are not limited to these embodiments. It is possible to appropriately combine each embodiment as long as the process contents do not contradict with each other.

First Embodiment

In a first embodiment, with reference to FIGS. **1** through **7**, descriptions are given to a configuration of an information processing system, a configuration of a storage device, a configuration of a control module (CM), process behaviors by the storage device, a process procedure by the storage device, effects, and the like.

Configuration of Information Processing System According to First Embodiment

FIG. **1** is a block diagram illustrating a configuration of an information processing system **1** according to the first embodiment. As illustrated in FIG. **1**, the information processing system **1** includes a host computer **2** and a storage device **10**. In the information processing system **1**, the host computer **2** is communicably connected with the storage device **10** via a fibre channel (FC), an internet small computer system interface (iSCSI), and the like. The number of host computers and the number of storage devices included in the information processing system **1** is not limited to illustrated numbers but modifiable.

The host computer **2** is, for example, a server and executes reading and writing of data of a logical volume to the storage device **10**.

The storage device **10** allocates a physical disk capacity by thin provisioning as the occasion arises in a case that an access is requested by the host computer **2**. For example, in a case of receiving a request for allocation of 10 TB from the host computer **2**, the storage device **10** allocates a virtual volume of 10 TB to the host computer **2** as requested, while actually allocating a physical disk capacity of only 2 TB. Then, in a case that the host computer **2** uses a physical disk capacity exceeding a predetermined threshold, the storage device **10** allocates a fresh additional physical disk capacity to the host computer **2**. The virtual volume used at this time is called as a thin provisioning volume (TPV), and a smallest unit of the physical disk capacity allocated to the TPV is called as a thin provisioning pool slice (TPPS). The disk capacity that the host computer **2** requests the storage device **10** to allocate and the capacity of the virtual volume and the physical disk capacity that is allocated to the host computer **2** by the storage device **10** are not limited as the above descriptions.

Configuration of Storage Device 10 According to First Embodiment

With reference to FIG. **1** consecutively, a configuration of the storage device **10** according to the first embodiment is described. The storage device **10** includes a channel adapter (CA) **11**, a CA **12**, a CA **13**, a CA **14**, a disk device **15**, a disk device **16**, a disk device **17**, a disk device **18**, a control module (CM) **20** and a CM **30**. The CAs **11**, **12**, **13**, and **14** are interfaces to the host computer **2**. The host computer **2** and the CAs **11**, **12**, **13**, and **14** are communicably connected with each other via an FC, an iSCSI, or the like.

The disk devices **15**, **16**, **17**, and **18** constitute redundant arrays of inexpensive disks (RAID) and store writing data received from the host computer **2**. The disk devices **15**, **16**, **17**, and **18** constitute TPVs, which are virtual volumes.

The CM **20** controls input/output of data between the host computer **2** and the disk devices **15** and **16**. The CM **30** controls input/output of data between the host computer **2** and the disk devices **17** and **18**. The number of CMs included in the storage device **10** is not limited to the illustrated number.

Configuration of CM 20 According to First Embodiment

With reference to FIG. **1** consecutively, a configuration of the CM **20** according to the first embodiment is described. As illustrated in FIG. **1**, the CM **20** includes a device adapter (DA) **21**, a DA **22**, a random access memory (RAM) **23**, a flash memory **24**, and a central processing unit (CPU) **25**.

The DA **21** is an interface to the disk device **15**, and the DA **22** is an interface to the disk device **16**.

The RAM **23** stores a mapping information table **23***a* and a copy management table **23***b*. The RAM **23** also stores pool management information, not illustrated, for managing a pool of unused TPPSs. The RAM **23** is substitutable with a dual inline memory module (DIMM), a dynamic random access memory (DRAM), or the like.

The mapping information table **23***a* stores mapping information that associates a logical address of a TPV achieved by the disk device with a physical address indicating a TPPS allocated in the TPV. The data structure of data stored in the mapping information table **23***a* is described later with reference to FIG. **2**.

The copy management table **23***b* stores information for managing whether or not data of a logical volume stored in the TPPS has been copied. The data structure of data stored in the copy management table **23***b* is described later with reference to FIG. **3**.

The flash memory **24** stores firmware **24***a*. The functional configuration of functions described in the firmware **24***a* is described later with reference to FIG. **4**. The CPU **25** loads and executes the firmware **24***a* stored in the flash memory **24**, thereby performing various types of arithmetic process.

Configuration of CM **30** According to First Embodiment

As illustrated in FIG. **1**, the CM **30** includes a DA **31**, a DA **32**, a RAM **33**, a flash memory **34**, and a CPU **35**. The DA **31** is an interface to the disk device **17**, and the DA **32** is an interface to the disk device **18**.

The RAM **33** stores a mapping information table **33***a* and a copy management table **33***b*. The mapping information table **33***a* stores information similar to the mapping information table **23***a*. The copy management table **33***b* stores information similar to the copy management table **23***b*. The RAM **33** also stores pool management information, not illustrated, for managing a pool of unused TPPSs. The RAM **33** is substitutable with a DIMM, a DRAM, or the like.

The flash memory **34** stores firmware **34***a*. The functional configuration of functions described in the firmware **34***a* is described later with reference to FIG. **4**. The CPU **35** loads and executes the firmware **34***a* stored in the flash memory **34**, thereby performing various types of arithmetic process.

The storage device **10** configured in such a manner executes the following process in a case that the CPU **25** has loaded the firmware **24***a* or in a case that the CPU **35** has loaded the firmware **34***a*. That is, the storage device **10** maintains, in the RAM, mapping information that associates a logical address of a TPV achieved by the disk device with a physical address indicating a TPPS allocated in the TPV. The storage device **10** executes the following process to the TPPS storing data of a logical volume subjected to copy in a case of being requested for release with a specified logical address that is associated with a physical address indicating the TPPS. That is, the storage device **10** deletes the TPPS from the mapping information and saves the TPPS from an access related to the TPV by the host computer **2**. Then, the storage device **10** updates the field of a physical address of the mapping information corresponding to the logical address to information indicating that a physical address is unallocated, allowing allocation of a physical address indicating a fresh TPPS to the logical address. Subsequently, the storage device **10** executes copy of data of the logical volume stored in the saved TPPS. After finishing the copy, the storage device **10** releases the TPPS storing the data of the logical volume subjected to the copy. That is to say, the physical address indicating this TPPS is registered in the pool management information for managing the pool of unused regions, thereby managing the physical address as an unused region after that. The mapping information table **23***a* (**33***a*), the copy management table **23***b* (**33***b*), and the pool management information that are stored in the storage device **10** are collectively referred to as "management information".

Data Structure of Data Stored in Mapping Information Table **23***a* (**33***a*)

Next, with reference to FIG. **2**, one example of data structure of data stored in the mapping information tables **23***a* and **33***a* is described. Since the data structure of data stored in the mapping information tables **23***a* and **33***a* are similar, the data structure of data stored in the mapping information table **23***a* is described here. In the following description, data stored in the mapping information tables **23***a* and **33***a* is appropriately mentioned as "mapping information".

FIG. **2** is a chart illustrating one example of a data structure of data stored in the mapping information table **23***a*. As illustrated in FIG. **2**, the mapping information table **23***a* stores information that associates a "logical LBA (logical block address)" with a "physical LBA". One LBA is 512 bytes.

A "logical LBA" stored in the mapping information table **23***a* represents a logical address in a TPV, which is a virtual region achieved by the disk devices **15**, **16**, **17**, and **18**. For example, a "logical LBA" has a value such as "1000" and "2000". The host computer **2** accesses the data of the logical volume stored in the TPPS by specifying the logical LBA. The host computer **2** also requests for release of the TPPS by specifying the logical LBA.

A "physical LBA" stored in the mapping information table **23***a* represents a physical address in a TPV, which is a virtual region achieved by the disk devices. For example, a "physical LBA" has a value such as "35000" and "47000".

The "physical LBA" is uniquely associated with an identifier of a TPPS. In other words, a "physical LBA" indicates a TPPS allocated in the TPV. For example, "35000" as a "physical LBA" is associated with a TPPS "TPPS_10", and "47000" as a "physical LBA" is associated with a TPPS "TPPS_22". In a case of accepting input/output process from the host computer **2** with a specified logical LBA, the storage device **10** executes the input/output process to the TPPS indicated by a physical LBA associated with the specified logical LBA.

In the example illustrated in FIG. **2**, the logical LBA "1000" in the TPV corresponds to the physical LBA "35000" and indicates the physical region identified by "TPPS_10". Similarly, the logical LBA "2000" in the TPV corresponds to the physical LBA "47000" and indicates the physical region identified by "TPPS_22".

The "physical LBA" stored in the mapping information table **23***a* is updated by a TPPS mapping management section **105** and a TPPS allocation management section **106** described later.

Data Structure of Data Stored in Copy Management Table **23***b* (**33***b*)

Next, with reference to FIG. **3**, one example of data structure of data stored in the copy management tables **23***b* and **33***b* is described. Since the data structure of data stored in the copy management tables **23***b* and **33***b* are similar, the data structure of data stored in the copy management table **23***b* is described here.

FIG. **3** is a chart illustrating one example of a data structure of data stored in the copy management table **23***b*. As illustrated in FIG. **3**, the copy management table **23***b* stores information that associates a "copy source TPPS", a "copy destination open logical unit (OLU)", a "copy destination logical LBA", and a "state" with each other.

Here, the "copy source TPPS" stored in the copy management table **23***b* represents an identifier of a TPPS of a copy source. For example, a "copy source TPPS" has a value such as "TPPS_11" and "TPPS_20".

The "copy destination OLU" stored in the copy management table **23***b* represents an identifier of an OLU of a copy destination. For example, a "copy destination OLU" has a value such as "1" and "2". The OLU is not a TPV managed by thin provisioning but a logical unit generally used in open systems.

The "copy destination logical LBA" stored in the copy management table **23***b* represents a logical address in the OLU of the copy destination. For example, a "copy destination logical LBA" has a value such as "5000" and "6000".

The "state" stored in the copy management table **23***b* represents a state of a copy process. For example, a "state" has a value such as "unexecuted" representing that the copy process is unexecuted, "in execution" representing that the copy process is in execution, or "finished" representing that the copy process is finished.

In the example illustrated in FIG. **3**, the copy management table **23***b* represents that process of copying the data of the logical volume stored in "TPPS_11" to the logical LBA "5000" of the OLU "1" is "finished". Similarly, the copy management table **23***b* represents that process of copying the data of the logical volume stored in "TPPS_11" to the logical LBA "6000" of the OLU "2" is "finished".

The "state" stored in the copy management table **23***b* is updated by a copy process control section **104** described later.

Functional Configuration of Functions Described in Firmware **24***a* (**34***a*)

Next, with reference to FIG. **4**, functional configurations of the functions described in the firmware **24***a* and **34***a* executed by the storage device **10** according to the first embodiment are described. Since the functional configurations of the functions described in the firmware **24***a* and **34***a* executed by the storage device **10** according to the first embodiment are similar, the firmware **24***a* and **34***a* are referred to as firmware **100** here for the description.

FIG. **4** is a diagram illustrating a functional configuration of functions described in firmware **100** executed by the storage device **10** according to the first embodiment. The functions described in the firmware **100** executed by the storage device **10** is achieved by the RAM **23** and the CPU **25** in cooperation or the RAM **33** and the CPU **35** in cooperation.

As illustrated in FIG. **4**, the functions described in the firmware **100** include an UNMAP command processing section **101**, a write I/O processing section **102**, a conflict detection section **103**, the copy process control section **104**, the TPPS mapping management section **105**, and the TPPS allocation management section **106**.

The UNMAP command processing section **101** receives an UNMAP command from the host computer **2**. Then, the UNMAP command processing section **101** causes the conflict detection section **103** described later to determine whether or not to copy data of the logical volume stored in the TPPS requested for release by the UNMAP command.

The UNMAP command processing section **101** suspends release of the TPPS requested for release in a case of being determined by the conflict detection section **103** to execute copy process of the data of the logical volume stored in the TPPS requested for release. Then, the UNMAP command processing section **101** causes the TPPS mapping management section **105** to update the mapping information table **23***a*. The UNMAP command processing section **101** releases the TPPS storing the data of the logical volume subjected to copy after finishing the copy of the data of the logical volume stored in the TPPS requested for release.

The UNMAP command processing section **101** releases the TPPS requested for release in a case of being determined by the conflict detection section **103** not to execute copy process of the data of the logical volume stored in the TPPS requested for release. Then, the UNMAP command processing section **101** causes the TPPS mapping management section **105** to update the mapping information table **23***a*.

The UNMAP command processing section **101** sends a response corresponding to the UNMAP command to the host computer **2** in a case of being informed that the mapping information table **23***a* is updated by the TPPS mapping management section **105**.

In a case of receiving a write I/O from the host computer **2** with a specified logical address, the write I/O processing section **102** writes the data of the logical volume in the TPPS indicated by the physical address allocated to the logical address.

For example, in a case of receiving a write I/O from the host computer **2** with a specified logical address, the write I/O processing section **102** requests the TPPS allocation management section **106** for allocation of a TPPS to the specified logical address. Then, the write I/O processing section **102** writes the write data received from the host computer **2** in the TPPS allocated by the TPPS allocation management section **106**. The write I/O processing section **102** responds to the host computer **2** for completion of the write I/O after writing the write data received from the host computer **2**.

The conflict detection section **103** determines whether or not to execute copy process of the TPPS requested for release. For example, the conflict detection section **103** reads out the "state" corresponding to the TPPS requested for release in the copy management table **23***b* and determines whether or not the "state" is "finished". In a case that the "state" in the copy management table **23***b* is "finished", the conflict detection section **103** determines not to execute copy process.

In a case that the "state" in the copy management table **23***b* is not "finished", that is, in a case that the "state" in the copy management table **23***b* is "in execution" or "unexecuted", the conflict detection section **103** determines to execute copy process.

The copy process control section **104** launches copy process of the data of the logical volume stored in the TPPS in the background. For example, in a case of executing copy process of the TPPS requested for release, the copy process control section **104** executes copy of the data of the logical volume stored in the saved TPPS.

The copy process control section **104** sets "in execution" for the "state" in the copy management table **23***b* in a case of executing the copy process, and sets "finished" for the "state" in the copy management table **23***b* in a case of finishing the copy process.

The TPPS mapping management section **105** updates the mapping information table **23***a* stored in the RAM **23** such that the TPPS requested for release by the host computer **2** becomes in a release state. For example, in a case of not executing copy of the TPPS requested for release, the TPPS mapping management section **105** updates the mapping information after the TPPS requested for release is released by the UNMAP command processing section **101**.

The TPPS mapping management section **105** also executes the following process to the TPPS storing the data of the logical volume subjected to copy in a case of being requested for release with a specified logical address that is associated with a physical address indicating the TPPS. That is, the TPPS mapping management section **105** saves the TPPS requested for release and updates the mapping information to be in a state of allowing allocation of a physical address indicating a fresh TPPS to the logical address specified in the request for release.

For example, the TPPS mapping management section **105** deletes a value stored in the "physical LBA" that is associated with the "logical LBA" indicating the TPPS requested for release. To cite one example, in a case of being requested for release with a specified logical LBA "2000", the TPPS mapping management section **105** deletes "36000" stored in the "physical LBA" corresponding to the logical LBA "2000".

In a case of accepting a request for writing data of a logical volume with the logical address specified in the request for release, the TPPS allocation management section **106** allocates a physical address indicating a fresh TPPS to the logical address. For example, the TPPS allocation management section **106** acquires a physical LBA indicating a new TPPS in association with the "logical LBA" requested for a write I/O. To cite one example, in a case of accepting a request for writing data of a logical volume with a specified logical LBA "2000", the TPPS allocation management section **106** stores "47000" in the "physical LBA" corresponding to the logical LBA "2000".

Process Behaviors by Storage Device **10** According to First Embodiment

Next, with reference to FIG. **5**, one example of process behaviors by the storage device **10** according to the first embodiment is described. FIG. **5** is a diagram illustrating one example of process behaviors by the storage device **10** according to the first embodiment. FIG. **5** illustrates a case that release of a TPPS **5***a* indicated by the logical LBA "2000" is requested and copy of the data of the logical volume stored in the TPPS **5***a* is unexecuted.

As illustrated in FIG. **5**, the storage device **10** receives an UNMAP command, from the host computer **2**, that requests for release of the TPPS **5***a* indicated by the logical LBA "2000" (S**101**). Since copy of the data of the logical volume stored in the TPPS **5***a* requested for release is unexecuted, the storage device **10** deletes the TPPS **5***a* from the mapping information and to update the mapping information table **23***a* (**33***a*) (S**102**). Accordingly, it is possible to save the TPPS **5***a* from the access related to the TPV by the host computer **2**.

Then, the storage device **10** sends a response to the UNMAP command to the host computer **2** (S**103**). Subsequently, the storage device **10** receives a write request to the TPPS indicated by the logical LBA "2000" from the host computer **2** (S**104**).

Since the logical LBA "2000" is in a state where no TPPS is allocated in the mapping information table **23***a* (**33***a*), the storage device **10** having the write request received therein acquires a new TPPS **5***b* for the logical LBA "2000" (S**105**). Then, the storage device **10** receives write data from the host computer **2** (S**106**), and sends a response to the write request to the host computer **2** (S**107**).

The storage device **10** executes copy of the data of the logical volume stored in the saved TPPS **5***a* (S**108**). Then, the storage device **10** releases the TPPS **5***a* after finishing the copy (S**109**).

Process Procedure of Process by Storage Device **10** According to First Embodiment

Next, with reference to FIGS. **6** and **7**, a process procedure of process by the storage device **10** according to the first embodiment is described. A process procedure of the mapping information update process upon receiving an UNMAP command in the storage device **10** is described with reference to FIG. **6**, and a process procedure of the TPPS acquisition process upon receiving a write I/O in the storage device **10** is described with reference to FIG. **7**.

Mapping Information Update Process Upon Receiving UNMAP Command

FIG. **6** is a flowchart illustrating a process procedure of mapping information update process upon receiving an UNMAP command in the storage device **10** according to the first embodiment. The mapping information update process upon receiving an UNMAP command is executed with an opportunity that the UNMAP command processing section **101** has received an UNMAP command.

As illustrated in FIG. **6**, the UNMAP command processing section **101** receives an UNMAP command from the host computer **2** (S**201**). Then, the conflict detection section **103** determines whether or not to execute copy process of the TPPS requested for release (S**202**).

Here, in a case of being determined to execute the copy process of the TPPS requested for release by the conflict detection section **103** (Yes in S**202**), the UNMAP command processing section **101** suspends release of the TPPS requested for release (S**203**). Then, the copy process control section **104** launches the copy process in the background (S**204**).

In contrast, in a case of being determined not to execute the copy process of the TPPS requested for release by the conflict detection section **103** (No in S**202**), the UNMAP command processing section **101** releases the TPPS requested for release (S**205**).

After finishing S**204** or S**205**, the TPPS mapping management section **105** updates the mapping information stored in the mapping information table **23***a* such that the TPPS requested for release from the host computer **2** becomes in a release state (S**206**). For example, the TPPS mapping management section **105** deletes a value stored in the "physical LBA" that is associated with the "logical LBA" indicating the TPPS requested for release.

After finishing the process of S**206**, the UNMAP command processing section **101** sends a response to the UNMAP command to the host computer **2** (S**207**), and finishes the mapping information update process.

TPPS Acquisition Process Upon Receiving Write I/O

FIG. **7** is a flowchart illustrating a process procedure of TPPS acquisition process when a write I/O has been received in the storage device according to the first embodiment. As illustrated in FIG. **7**, the write I/O processing section **102** receives a write I/O from the host computer **2** (S**301**).

Then, the write I/O processing section **102** requests the TPPS allocation management section **106** to acquire a TPPS for the logical LBA requested for a write I/O. This causes the TPPS allocation management section **106** to acquire a new TPPS for the logical LBA requested by the write I/O processing section **102** (S**302**).

Subsequently, the write I/O processing section **102** receives write data from the host computer **2** after a new TPPS is acquired by the TPPS allocation management section **106** (S**303**), and responds to the host computer **2** (S**304**).

Effects of First Embodiment

In a case that an UNMAP command is issued, the storage device **10** according to the first embodiment does not put the TPPS requested for release in an UNMAP reservation state but updates the mapping information of the logical LBA and the physical LBA to a state of allowing allocation of another new TPPS. After that, the storage device **10** controls an access from the host computer **2** to access a newly allocated TPPS and copy process within the storage device **10** to access the originally allocated TPPS requested for release. Then, the storage device **10** releases the TPPS requested for release at the time when the copy is completed and the information in the TPPS requested for release becomes unused. The storage device **10** pools the TPPS in the pool of a physical disk capacity as an unused region. This enables the UNMAP command process and the copy process to be independent from each other and the storage device **10** to avoid a possibility that a write I/O is timed out.

Second Embodiment

In the first embodiment, a case that the storage device **10** is requested for release of the TPPS storing the data of the logical volume subjected to copy is described. In the storage device **10**, there is a case that an UNMAP command and copy of a snapshot type are executed alternately and repeatedly to an identical logical LBA. In this case, the storage device **10** is requested for release of the TPPS storing the data of the logical volume subjected to copy, and also executes new copy to data of a logical volume stored in a TPPS that is newly associated with the logical address specified in the request for release.

With that, a second embodiment represents an example that a storage device stores copy information that associates a saving generation number of copy generation, an identifier of a TPPS storing copy source data, and a logical address indicating a copy destination with each other.

Configuration of Information Processing System 1 According to Second Embodiment

FIG. **8** is a block diagram illustrating a configuration of an information processing system **1** according to the second embodiment. The information processing system **1** according to the second embodiment includes the host computer **2** and the storage device **10**. The configuration of the information processing system **1** according to the second embodiment is similar to the configuration of the information processing system according to the first embodiment illustrated in FIG. **1** other than that a part of the tables and the functional configuration of the firmware maintained in the CMs **20** and **30** are different. Therefore, identical reference numerals are given to functional sections playing roles similar to those of the sections illustrated in FIG. **1** to omit detailed descriptions thereof.

Configuration of CM 20 According to Second Embodiment

With reference to FIG. **8** consecutively, the configuration of the CM **20** according to the second embodiment is described. As illustrated in FIG. **8**, the CM **20** includes a DA **21**, a DA **22**, a RAM **23**, a flash memory **24**, and a CPU **25**.

The RAM **23** stores a mapping information table **23**_a_, a copy management table **23**_b_, and a copy generation management table **23**_c_. The RAM **23** also stores pool management information, not illustrated, for managing a pool of unused TPPSs.

The copy generation management table **23**_c_ stores copy information that associates a saving generation number of copy generation, an identifier of a TPPS storing copy source data, and a logical address indicating a copy destination with each other. The data structure of data stored in the copy generation management table **23**_c_ is described later with reference to FIG. **9**.

The flash memory **24** stores firmware **24**_a_. The functional configuration of functions described in the firmware **24**_a_ is described later with reference to FIG. **10**. The CPU **25** loads and executes the firmware **24**_a_ stored in the flash memory **24**, thereby performing various types of arithmetic process. The configuration of the CM **30** is similar to that of the CM **20**.

Data Structure of Data Stored in Copy Generation Management Table 23c (33c)

Next, with reference to FIG. **9**, the data structure of data stored in the copy generation management table **23**_c_ and a copy generation management table **33**_c_ are described. Since the data structure of data stored in the copy generation management table **23**_c_ is similar to the data structure of data stored in the copy generation management table **33**_c_, the data structure of data stored in the copy generation management table **23**_c_ is described here.

FIG. **9** is a chart illustrating one example of a data structure of data stored in the copy generation management table **23**_c_. As illustrated in FIG. **9**, the copy generation management table **23**_c_ stores information that associates a "copy generation", a "copy source TPPS", a "copy destination OLU", and a "copy destination logical LBA" with each other.

Here, a "copy generation" stored in the copy generation management table **23**_c_ represents a saving generation number of copy generation. In other words, the "copy generation" represents how many times an UNMAP command and copy of a snapshot type are executed alternately and repeatedly to an identical logical LBA. For example, the "copy generation" has a value such as "1" and "2".

The "copy source TPPS" stored in the copy generation management table **23**_c_ represents an identifier of the TPPS of the copy source. For example, the "copy source TPPS" has a value such as "TPPS_11" and "TPPS_20".

The "copy destination OLU" stored in the copy generation management table **23**_c_ represents an identifier of the OLU of the copy destination. For example, the "copy destination OLU" has a value such as "1" and "2". The OLU is a logical unit generally used in open systems.

The "copy destination logical LBA" stored in the copy generation management table **23**_c_ represents a logical address in the OLU of the copy destination. For example, the "copy destination logical LBA" has a value such as "5000" and "6000".

In the example illustrated in FIG. **9**, the copy generation management table **23**_c_ represents that the data of the logical volume stored in the "TPPS_11" is copied to the logical LBA "5000" of the OLU "1" as a first generation. Similarly, the copy generation management table **23**_c_ represents that the data of the logical volume stored in the "TPPS_11" is copied to the logical LBA "6000" of the OLU "2" as a second generation.

The copy generation management table **23**_c_ represents that the data of the logical volume stored in the "TPPS_20" is copied to the logical LBA "7000" of the OLU "3" as a third generation.

Functional Configuration of Functions Described in Firmware 24a (34a)

Next, with reference to FIG. **10**, functional configurations of the functions described in the firmware **24**_a_ and **34**_a_ executed by the storage device **10** according to the second embodiment are described. Since the functional configurations of the functions described in the firmware **24**_a_ and **34**_a_ executed by the storage device **10** according to the second embodiment are similar, the firmware **24***a* and **34***a* are referred as firmware **200** here for the description.

FIG. **10** is a diagram illustrating one example of a functional configuration of functions described in firmware **200** executed by the storage device **10** according to the second embodiment. As illustrated in FIG. **10**, the functions described in the firmware **200** include the UNMAP command processing section **101**, the write I/O processing section **102**, the conflict detection section **103**, the copy process control section **104**, the TPPS mapping management section **105**, and the TPPS allocation management section **106**. As illustrated in FIG. **10**, the functions described in the firmware **200** include a TPPS generation management section **201** and a copy generation process control section **202**. Identical reference numerals are given to sections having functions similar to the functions described in the firmware **100** illustrated in FIG. **4** to omit detailed descriptions.

The TPPS generation management section **201** executes the following process in a case of executing copy process to data stored in a physical address that is freshly associated with the logical address specified in the request for release upon accepting a request for release of the TPPS storing the data subjected to copy. That is, the TPPS generation management section **201** gives a saving generation number to carry out copy process and causes the given saving generation number to be stored in the copy generation management table **23***c*, thereby managing generations of the TPPS.

The copy generation process control section **202** executes the following process in a case of executing copy process to the data stored in the physical address that is freshly associated with the logical address specified in the request for release upon accepting a request for release of the TPPS storing the data subjected to copy. That is, the copy generation process control section **202** causes the copy information that associates an identifier of a TPPS storing copy source data and a logical address indicating a copy destination in association with a saving generation number of copy generation to be stored in the copy generation management table **23***c*. For example, the copy generation process control section **202** causes a pair of the TPPS of the copy source and the OLU of the copy destination to be stored in the copy generation management table **23***c* for each copy generation.

The copy process control section **104** executes copy process for each saving generation number of copy generation with reference to the copy generation management table **23***c*.

Process Behaviors by Storage Device **10** According to Second Embodiment

Next, with reference to FIG. **11**, one example of process behaviors by the storage device **10** according to the second embodiment is described. FIG. **11** is a diagram illustrating one example of process behaviors by the storage device **10** according to the second embodiment. FIG. **11** illustrates a case that release of the TPPS indicated by the logical LBA "2000" and copy of the data of the logical volume stored in the TPPS indicated by the logical LBA "2000" are executed alternately.

As illustrated in FIG. **11**, the storage device **10** executes copy (mentioned as copy[A]) of the data of the logical volume stored in a TPPS (mentioned as TPPS[A]) indicated by the logical LBA "2000" (S**401**). The storage device **10** also executes copy (mentioned as copy[B]) of the data of the logical volume stored in the TPPS[A] indicated by the logical LBA "2000" (S**402**).

The storage device **10** receives an UNMAP command, from the host computer **2**, that requests for release of the TPPS[A] indicated by the logical LBA "2000". Since the copy of the data of the logical volume stored in the TPPS[A] requested for release is in execution, the storage device **10** manages the TPPS[A] indicated by the logical LBA "2000" as a first generation. The storage device **10** also deletes the TPPS[A] from the mapping information to update the mapping information table **23***a* (**33***a*) (S**403**). Accordingly, it is possible to save the TPPS[A] from an access related to the TPV by the host computer **2**. Then, the storage device **10** sends a response to the UNMAP command to the host computer **2**.

Subsequently, the storage device **10** receives a write request, from the host computer **2**, to the TPPS indicated by the logical LBA "2000". The storage device **10** acquires a new TPPS (mentioned as TPPS[B]) for the logical LBA "2000" upon receiving the write request.

Then, the storage device **10** receives write data from the host computer **2** and sends a response to the write request to the host computer **2**. The storage device **10** also executes copy (mentioned as copy[C]) of the data of the logical volume stored in the TPPS[B] (S**404**).

Subsequently, the storage device **10** receives an UNMAP command, from the host computer **2**, that requests for release of the TPPS[B] indicated by the logical LBA "2000". Since the copy of the data of the logical volume stored in the TPPS[B] requested for release is in execution, the storage device **10** manages the TPPS[B] indicated by the logical LBA "2000" as a second generation. The storage device **10** also deletes the TPPS[B] from the mapping information to update the mapping information table **23***a* (**33***a*) (S**405**). Accordingly, it is possible to save the TPPS[B] from an access related to the TPV by the host computer **2**. Then, the storage device **10** sends a response to the UNMAP command to the host computer **2**.

Subsequently, the storage device **10** receives a write request, from the host computer **2**, to the TPPS indicated by the logical LBA "2000". The storage device **10** acquires a new TPPS (mentioned as TPPS[C]) for the logical LBA "2000" upon receiving the write request.

Then, the storage device **10** receives write data from the host computer **2** and sends a response to the write request to the host computer **2**. The storage device **10** also executes copy (mentioned as copy[D]) of the data of the logical volume stored in the TPPS[C] (S**406**).

Subsequently, the storage device **10** receives an UNMAP command, from the host computer **2**, that requests for release of the TPPS[C] indicated by the logical LBA "2000". Since the copy of the data of the logical volume stored in the TPPS[C] requested for release is in execution, the storage device **10** manages the TPPS[C] indicated by the logical LBA "2000" as a third generation. The storage device **10** also deletes the TPPS[C] from the mapping information to update the mapping information table **23***a* (**33***a*) (S**407**). Accordingly, it is possible to save the TPPS[C] from an access related to the TPV by the host computer **2**. The storage device **10** acquires a new TPPS (mentioned as TPPS[D]) for the logical LBA "2000" in a case of receiving a write request, from the host computer **2**, to the TPPS indicated by the logical LBA "2000".

The storage device **10** releases the TPPS[A] in the first generation after finishing the copy[A] and the copy[B] of the TPPS[A] (S**408**). The storage device **10** also releases the TPPS[B] in the second generation after finishing the copy[C] of the TPPS[B] (S**409**). Similarly, the storage device **10** releases the TPPS[C] in the third generation after finishing the copy[D] of the TPPS[C] (S**410**).

Process Procedure of Process by Storage Device **10** According to Second Embodiment

Next, with reference to FIG. **12**, a process procedure of the mapping information update process by the storage device **10** according to the second embodiment is described. FIG. **12** is a flowchart illustrating a process procedure of mapping information update process by the storage device **10** according to the second embodiment.

As illustrated in FIG. **12**, the UNMAP command processing section **101** receives an UNMAP command (S**501**). Then, the conflict detection section **103** determines whether or not to execute the copy process of the TPPS requested for release (S**502**).

Here, in a case of being determined to execute the copy process of the TPPS requested for release by the conflict detection section **103** (Yes in S**502**), the UNMAP command processing section **101** does not immediately release the TPPS requested for release (S**503**).

Then, the TPPS generation management section **201** gives a saving generation number to carry out the copy process to be stored in the copy generation management table **23***c* (S**504**). The copy generation process control section **202** causes the copy information that associates an identifier of a TPPS storing copy source data with a logical address indicating a copy destination to be stored in the copy generation management table **23***c* (S**505**).

Subsequently, the copy process control section **104** determines whether or not there are a plurality of items of copy process (S**506**). Here, in a case of determining that there are a plurality of items of copy process (Yes in S**506**), the copy process control section **104** launches the plurality of items of copy process in the background (S**507**). In contrast, in a case of determining that there is only one item of copy process (No in S**506**), the copy process control section **104** launches the copy process in the background (S**508**).

In contrast, in a case of being determined not to execute copy process of the TPPS requested for release by the conflict detection section **103** (No in S**502**), the UNMAP command processing section **101** releases the TPPS requested for release (S**509**).

After finishing S**507**, S**508**, or S**509**, the TPPS mapping management section **105** updates the mapping information stored in the mapping information table **23***a* such that the TPPS requested for release from the host computer **2** becomes in a release state (S**510**).

Subsequently, the UNMAP command processing section **101** sends a response to the UNMAP command to the host computer **2** (S**511**) and finishes the mapping information update process.

Effects of Second Embodiment

As described above, the storage device **10** according to the second embodiment is capable of managing a pair of a "copy source" and a "copy destination" for each generation.

Third Embodiment

In the first and second embodiments, the copy is executed by taking an OLU as a copy destination in a case that the storage device **10** copies the data of the logical volume stored in the TPPS requested for release. The storage device **10** may also take a TPV, not an OLU, as a copy destination.

In such a case, the storage device **10** may also updates the mapping information table **23***a* or **33***a* for the copy destination without executing copy process.

With that, in a third embodiment, a case that the copy process control section **104** has the following functions is described. The copy process control section **104** according to the third embodiment executes the following process in a case that the copy destination of the data of the logical volume stored in the saved TPPS is a TPV. That is, the copy process control section **104** associates the logical LBA of the TPV in the copy destination with the physical LBA indicating the TPPS to be stored in the mapping information table **23***a*.

Process Procedure of Process by Storage Device **10** According to Third Embodiment

With reference to FIG. **13**, the process procedure of the process by the storage device **10** according to the third embodiment is described. FIG. **13** is a flowchart illustrating a process procedure at the time of copy to a TPV by the storage device **10** according to the third embodiment. FIG. **13** illustrates a case of copying the TPPS_22 indicated by the logical LBA "2000" to the logical LBA "9000" of the TPV.

As illustrated in FIG. **13**, the UNMAP command processing section **101** receives an UNMAP command (S**601**). Then, the conflict detection section **103** determines whether or not to execute the copy process of the TPPS requested for release (S**602**).

Here, in a case of being determined to execute the copy process of the TPPS requested for release by the conflict detection section **103** (Yes in S**602**), the UNMAP command processing section **101** suspends release of the TPPS requested for release (S**603**). Then, the copy process control section **104** determines whether or not the copy destination is a TPV (S**604**).

In a case of determining that the copy destination is not a TPV (No in S**604**), the copy process control section **104** launches the copy process in the background (S**605**). In contrast, in a case of determining that the copy destination is a TPV (Yes in S**604**), the copy process control section **104** determines to omit the copy process in the background (S**606**). Then, the copy process control section **104** updates the mapping information for the copy destination instead of executing the copy process (S**607**). For example, the copy process control section **104** causes information that associates the logical LBA "9000" with the TPPS_22 to be stored in the mapping information table **23***a* as the mapping information for the copy destination.

In contrast, in a case of being determined not to execute the copy process of the TPPS requested for release by the conflict detection section **103** (No in S**602**), the UNMAP command processing section **101** releases the TPPS requested for release (S**608**).

After finishing S**605**, S**607**, or S**608**, the TPPS mapping management section **105** updates the mapping information such that the TPPS requested for release from the host computer **2** becomes in a release state (S**609**). For example, the TPPS mapping management section **105** deletes a value stored in the "physical LBA" that is associated with the logical LBA "2000".

Then, the UNMAP command processing section **101** sends a response to the UNMAP command to the host computer **2** (S**610**) and finishes the process.

Effects of Third Embodiment

In such a manner, in a case that the copy destination of the TPPS requested for release is a TPV, the storage device may omit the copy process. The process of omitting the copy process may be combined with the process of managing the copy generation.

Next, with reference to FIG. **14**, one example of process behaviors to combine the process of omitting copy process with the process of managing the copy generation by the storage device **10** according to the third embodiment is described. FIG. **14** is a diagram illustrating one example of process behaviors by the storage device **10** according to the third embodiment. FIG. **14** illustrates a case that release of the TPPS indicated by the logical LBA "2000" and copy of the data of the logical volume stored in the TPPS indicated by the logical LBA "2000" are executed alternately and that the copy destination is a TPV.

As illustrated in FIG. **14**, the storage device **10** receives an UNMAP command, from the host computer **2**, that requests for release of the TPPS[A] indicated by the logical LBA "2000". Here, in a case of executing copy (mentioned as copy[A]) of the data of the logical volume stored in a TPPS (mentioned as TPPS[A]) requested for release, the storage device **10** manages the TPPS[A] indicated by the logical LBA "2000" as a first generation. The storage device **10** also deletes the TPPS[A] from the mapping information to update the mapping information table **23***a* (**33***a*). Accordingly, it is possible to save the TPPS[A] from the access related to the TPV by the host computer **2**. Since the copy destination is a TPV, the storage device **10** determines to omit copy process and updates the mapping information for the copy destination instead of executing the copy process (S**701**).

After finishing the copy[A], the storage device **10** executes copy (mentioned as copy[B]) of the data of the logical volume stored in the TPPS[A] (S**702**). In this case, since the copy source is the already saved TPPS[A], the storage device **10** physically copies the data of the logical volume stored in the TPPS[A].

Subsequently, the storage device **10** receives a write request, from the host computer **2**, to the TPPS indicated by the logical LBA "2000". The storage device **10** acquires a new TPPS (mentioned as TPPS[B]) for the logical LBA "2000".

Then, the storage device **10** receives an UNMAP command, from the host computer **2**, that requests for release of the TPPS[B] indicated by the logical LBA "2000". Here, in a case of executing copy (mentioned as copy[C]) of the data of the logical volume stored in the TPPS[B] requested for release, the storage device **10** manages the TPPS[B] indicated by the logical LBA "2000" as a second generation. The storage device **10** also deletes the TPPS[B] from the mapping information to update the mapping information table **23***a* (**33***a*). Accordingly, it is possible to save the TPPS[B] from the access related to the TPV by the host computer **2**. Since the copy destination is a TPV, the storage device **10** determines to omit copy process and updates the mapping information for the copy destination instead of executing the copy process (S**703**).

Subsequently, the storage device **10** receives a write request, from the host computer **2**, to the TPPS indicated by the logical LBA "2000". The storage device **10** acquires a new TPPS (mentioned as TPPS[C]) for the logical LBA "2000".

Then, the storage device **10** receives an UNMAP command, from the host computer **2**, that requests for release of the TPPS[C] indicated by the logical LBA "2000". Here, in a case of executing copy (mentioned as copy[D]) of the data of the logical volume stored in the TPPS[C] requested for release, the storage device **10** manages the TPPS[C] indicated by the logical LBA "2000" as a third generation. The storage device **10** also deletes the TPPS[C] from the mapping information to update the mapping information table **23***a* (**33***a*). Accordingly, it is possible to save the TPPS[C] from the access related to the TPV by the host computer **2**. Since the copy destination is a TPV, the storage device **10** determines to omit copy process and updates the mapping information for the copy destination instead of executing the copy process (S**704**).

Subsequently, the storage device **10** receives a write request, from the host computer **2**, to the TPPS indicated by the logical LBA "2000". The storage device **10** acquires a new TPPS (mentioned as TPPS[D]) for the logical LBA "2000".

After finishing the copy[A] and the copy[B] of the TPPS [A] in the first generation, the storage device **10** releases the TPPS[A]. After finishing the copy[C] of the TPPS[B] in the second generation, the storage device **10** releases the TPPS [B]. Similarly, after finishing the copy[D] of the TPPS[C] in the third generation, the storage device **10** releases the TPPS [C].

System Configuration

The embodiments may be implemented in a variety of different modes other than the embodiments described above. Among each items of process described in the embodiments, all or part of the process described to be executed automatically may also be executed manually. Alternatively, all or part of the process described to be executed manually may also be executed automatically in an existing method. Other than them, the process procedure, the control procedure, and the specific names represented in the above description and the drawings may be optionally modified unless otherwise specified.

In accordance with various types of load, status of use, and the like, the order of process may also be modified in the process described in each embodiment.

Each of the illustrated components is functionally conceptual and is not desired to be physically configured as illustrated. For example, among the functions of the firmware **200** executed by the storage device **10**, the TPPS generation management section **201** and the copy generation process control section **202** may be integrated. Further, each process function executed in each device may be achieved by a CPU and a program analyzed and executed by the CPU or achieved as hardware by a wired logic in its all or an optional part.

All examples and conditional language recited herein are intended for pedagogical purposes to aid the reader in understanding the invention and the concepts contributed by the inventor to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions, nor does the organization of such examples in the specification relate to a showing of the superiority and inferiority of the invention. Although the embodiments of the present invention have been described in detail, it should be understood that the various changes, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention.

What is claimed is:

1. A storage device comprising:

a memory; and

a control device to

allocate a first storage region out of a plurality of storage regions to a first logical address specified by an external device,

store, in the memory, first information associating the first logical address with a first physical address indicating the first storage region,

delete, upon accepting a request for release of a second storage region indicated by a second physical address associated with a second logical address specified by the external device, second information associating the second logical address with the second physical address from the memory,

acquire, upon receiving a request for writing data with the second logical address, a third storage region out of the plurality of storage regions for the second logical address,

store, in the memory, third information associating the second logical address with a third physical address indicating the third storage region, and

release, after the third storage region has been acquired and when a copy process of copying first data stored in the second storage region has not been executed, the second storage region after finishing the copy process.

2. The storage device according to claim **1**, wherein the control device

stores, when the first data is subjected to copy and when executing the copy process to second data stored in the third storage region indicated by the third physical address newly associated with the second logical address, copy information associating a generation number of copy generation, an identifier of the third storage region, and a third logical address indicating a copy destination in the memory, and

executes a copy process for each generation number with reference to the copy information.

3. The storage device according to claim **1**, wherein

the control device stores, when a copy destination of the copy process is a virtual region, the third information associating the third logical address of the copy destination with the second physical address in the memory.

4. A method for controlling a storage device including a memory and a control device, the method comprising:

allocating, by the control device, a first storage region out of a plurality of storage regions to a first logical address specified by an external device;

storing, in the memory, first information associating the first logical address with a first physical address indicating the first storage region;

deleting, upon accepting a request for release of a second storage region indicated by a second physical address associated with a second logical address specified by the external device, second information associating the second logical address with the second physical address from the memory;

acquiring, upon receiving a request for writing data with the second logical address, a third storage region out of the plurality of storage regions for the second logical address;

storing, in the memory, third information associating the second logical address with a third physical address indicating the third storage region; and

releasing, after the third storage region has been acquired and when a copy process of copying first data stored in the second storage region has not been executed, the second storage region after finishing the copy process.

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